

Ground Operations Autonomous Control and Integrated Health Management

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An intelligent autonomous control capability has been developed and is currently being validated in ground cryogenic fluid management operations. The capability embodies a physical architecture consistent with typical launch infrastructure and control systems, augmented by a higher level autonomous control (AC) system enabled to make knowledge-based decisions. The AC system is supported by an integrated system health management (ISHM) capability that detects anomalies, diagnoses causes, determines effects, and could predict future anomalies. AC is implemented using the concept of programmed sequences that could be considered to be building blocks of more generic mission plans. A sequence is a series of steps, and each executes actions once conditions for the step are met (e.g. desired temperatures or fluid state are achieved). For autonomous capability, conditions must consider also health management outcomes, as they will determine whether or not an action is executed, or how an action may be executed, or if an alternative action is executed instead. Aside from health, higher level objectives can also drive how a mission is carried out. The capability was developed using the G2 software environment (www.gensym.com) augmented by a NASA Toolkit that significantly shortens time to deployment. G2 is a commercial product to develop intelligent applications. It is fully object oriented. The core of the capability is a Domain Model of the system where all elements of the system are represented as objects (sensors, instruments, components, pipes, etc.). Reasoning and decision making can be done with all elements in the domain model. The toolkit also enables implementation of failure modes and effects analysis (FMEA), which are represented as root cause trees. FMEA's are programmed graphically, they are reusable, as they address generic FMEA referring to classes of subsystems or objects and their functional relationships. User interfaces for integrated awareness by operators have been created.